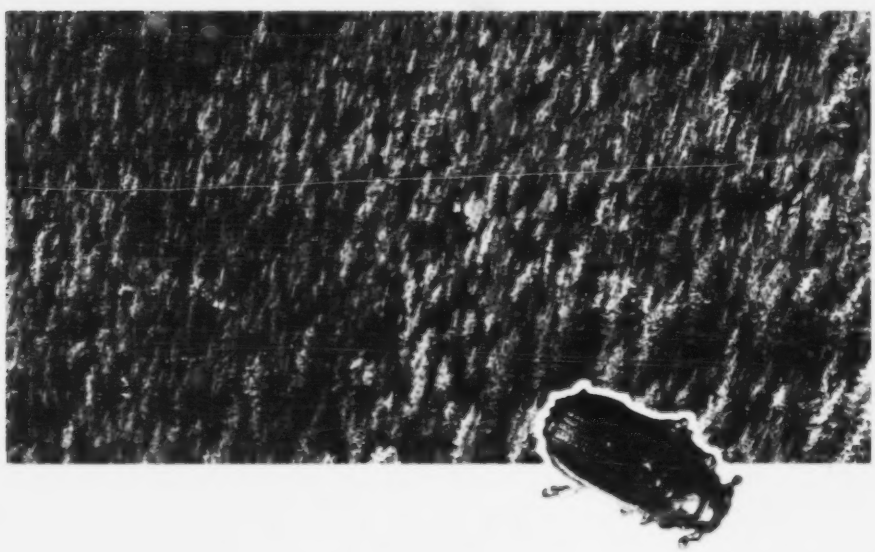
Mountain Pine Beetle Management

A guide for small woodland operations



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Mountain Pine Beetle Management

A guide for small woodland operations

Natural Resources Canada
Canadian Forest Service
Pacific Forestry Centre

Mountain Pine Beetle Initiative

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Cover image: The adult mountain pine beetle (which range from 3.7 to 7.5 mm in length) and a forest damaged by it.

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Adult mountain pine beetles range from 3.7 to 7.5 mm in length.

Introduction

This guide, written for non-foresters, is about the management of the mountain pine beetle on small-scale woodlands including woodlots, private lands, and First Nations lands. If your small woodland lies adjacent to or within areas of significant mountain pine beetle infestations, information on prevention, detection and management will help you reduce losses to this pest.

This guide will not tell you everything there is to know about the mountain pine beetle but will help you detect the presence of the insect in your stand and aid you in making decisions. More detail is available from the resources listed at the back of this guide. There you will find contact information for both key organizations and government agencies.

To see an animation of the historic (since 1959) occurrence of the mountain pine beetle, go to www.pfc.cfs.nrcan.gc.ca/entomology/mpb/historical.

Why the Mountain Pine Beetle?

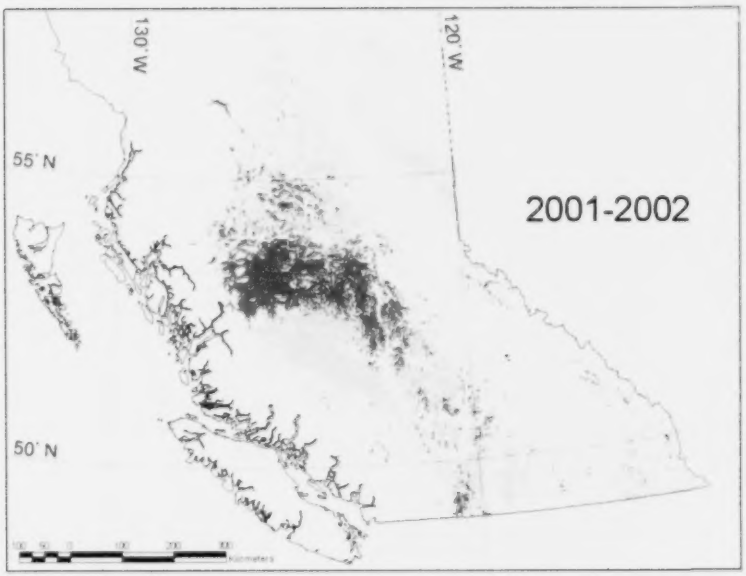
Bark beetles are among the most serious pests of mature lodgepole pine, spruce, Douglas-fir and subalpine fir in British Columbia (BC). The BC Ministry of Forests estimates that the mountain pine beetle has affected (in varying degrees of severity) approximately 4.2 million hectares of pine forests. This estimate, based on preliminary results of 2003 aerial surveys, indicates that the rate of spread has doubled since the 2 million hectares reported in 2002.

The mountain pine beetle is endemic in British Columbia north to about 56° latitude and on the southern part of east slopes of the Rocky Mountains in Alberta. In addition, the mountain pine beetle has been recorded from the Cypress Hills in southeast Alberta and adjacent Saskatchewan. Infestations have been recorded from sea level to the highest elevations where the host species grow. The principal native host is lodgepole pine. Other native hosts include ponderosa (yellow) pine, western white pine, whitebark pine, and limber pine. Outbreaks generally last 8-10 years and severely deplete the pine component of forest stands.

Mountain pine beetle outbreaks cause extensive tree mortality and modify stand structure by reducing the average tree diameter, height and stand density.

The Mountain Pine Beetle Initiative

In October 2002, the Government of Canada announced a Mountain Pine Beetle Initiative (MPBI) in response to the epidemic. Although funded by the federal government, the MPBI is delivered through partnerships with several federal departments, the Government of British Columbia, national research institutes, First Nations, and industry. It focuses on research to quantify the impacts of the mountain pine beetle and reduce the risk of subsequent epidemics. It also provides support for the rehabilitation of federal and private forestlands ravaged by the mountain pine beetle, including national parks, First Nations reserves and non-industrial private lands. Further information about the MPBI including how to access funding is available at mpb.cfs.nrcan.gc.ca.



Distribution of mountain pine beetle outbreak (red) among pine-leading stands (green) in British Columbia, 2001-2002.

Mountain Pine Beetles

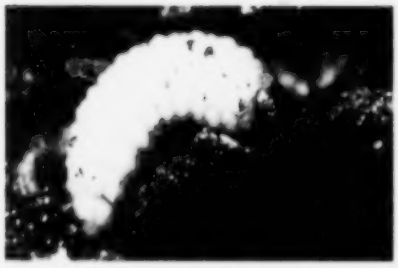
Description and Life Cycle

The mountain pine beetle develops from egg to larva, then pupa to adult. Except for a few days during the summer when adults emerge and fly to new trees, these beetles spend all stages of their lives under the bark of infested trees.

Adults are hard, stout-bodied, cylindrical insects ranging from 3.7 to 7.5 mm in length. They have black heads and thoraxes, and black or brownish bodies. Eggs are white, about 1 mm in size, and are laid singly in niches on both sides of the parent gallery. Larvae are white legless grubs with red-brown heads, about 5 mm long in the fourth (final) stage. Pupae are white at first, changing to light brown, with the external characteristics of the adult beetle visible. Immature adults are light creamy-tan in colour, changing to black when mature.

The normal life cycle of the mountain pine beetle takes one year to complete. Females bore through the bark to the cambium region, where they begin construction of the egg gallery and brood in the phloem. Broods overwinter mainly as larvae. They resume feeding in April and complete development in June. When the larvae mature, they turn into pupae for a short period, becoming adults in mid-summer. The newly formed adults spend a brief period feeding under the bark before they bore through it and emerge as mature adults in mid-July through early September, ready to attack a new host.

During warmer than average summers, parent adults may re-emerge and establish a second brood in the same year. Conversely, in cooler summers or at higher elevations, broods may require up to two years to mature.



Mountain pine beetle larvae are white, legless and curled.

Under the bark, female beetles construct straight, vertical egg galleries.

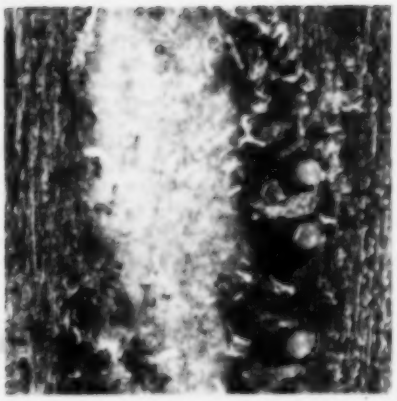
How Mountain Pine Beetles Kill Trees

As mentioned above, female adult beetles bore through the bark of host trees and construct the egg gallery in the cambium region. The galleries are straight or slightly curved, usually following the grain of the wood, with a short crook or bend at the bottom where there is boring dust. The galleries are about 30 cm long but occasionally may reach 90 cm in length. They extend upward and usually score both bark and sapwood.

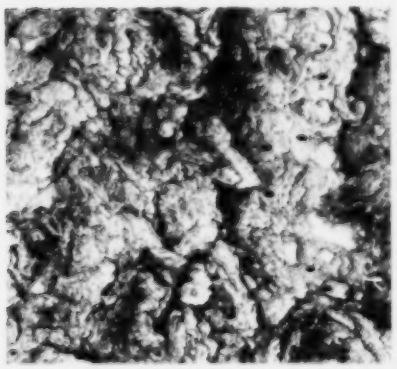
Cambium: A single layer of cells between the woody part of the tree and the inner bark.

Xylem: The principal strengthening and water conducting tissue of stems, leaves and roots.

Phloem: A layer of tree tissue just inside the outer bark that conducts food from the leaves to the stem and roots.



Pupal chambers are hollowed into the outer bark where larvae pupate and new adults emerge.



Entrance holes on lodgepole pines are visible during the attack period. Exit holes will appear during the following emergence period.

The first female mountain pine beetles that attack the tree emit a pheromone that attracts mainly males. The males, in turn, emit pheromones that attract additional females. This leads to a mass attack which overcomes the tree's resistance.

Fungi, which are introduced by the beetle and produce blue stain in the sapwood, begin to grow in the phloem and xylem soon after the beetles start their galleries. As the fungi become established they interrupt the flow of water to the crown and reduce the tree's pitch flow, which is its main defense mechanism against beetle attack. Successfully established blue stain fungi will also retain moisture in the sapwood and prevent excessive dehydration of the phloem, which is essential for brood survival. The combined action of the beetle and fungi kills the tree.

Hosts

The principal host for the mountain pine beetle is large-diameter (trees with diameters greater than 25 cm are particularly susceptible), mature (over 60 years old) lodgepole pine. Other native hosts include ponderosa (yellow) pine, western white pine, whitebark pine, and limber pine.

In epidemic conditions, the mountain pine beetle has been observed in lodgepole pine of various ages, diameters and heights. However, bigger trees are thought to provide more and higher quality food and larval habitat. Thicker bark provides greater protection from predators and temperature extremes.

When lodgepole pine is young, it is usually able to resist inoculation with the blue stain fungus. Resistance increases up to about age 60 and then declines rapidly. By the time stands reach 80 to 100 years of age, most trees have a low resistance to the fungus.

Dispersal and Colonization

Emergence and Flight: Adult mountain pine beetles emerge and fly in mid to late summer when air temperatures reach 18° to 19°C and the host trees are under the most stress from water deficiency. The peak of flight activity occurs at about 25°C. In a normal summer, mountain pine beetle flight from a single source spans two to ten days. Mountain pine beetles do not fly in heavy rain or under very windy conditions. In cool weather, the flight may last four to six weeks.

Dispersal: Following emergence, mountain pine beetles disperse to colonize new trees and stands. Dispersal may be either short range (within stands or between adjacent stands) or long range, in which mountain pine beetles leave the stand altogether, often flying above the canopy for up to 40 km when utilizing wind currents.

Colonization: Pioneer mountain pine beetles forage within stands until they encounter a suitable host, normally larger-diameter trees. Many of these larger trees are stressed, often because of low water levels on the site. Stressed trees have limited ability to produce the resin necessary to 'pitch' out the invading mountain pine beetle. Stand conditions, such as light, heat and wind, affect foraging success.

Small, (incipient) infestations often develop in elevated spots or in weakened stands on south-facing slopes that have a low site index or are drought-stressed. However, these incipient infestations can develop wherever host and site conditions are suitable. After these pioneer mountain pine beetle populations have grown in size they colonize the surrounding area.

Natural Control Factors

Temperature: Nature's most effective population control for mountain pine beetle is cold: temperatures below -40°C kill beetles at all brood stages. However, as winter temperatures decline, the mountain pine beetle larvae (the usual overwintering stage) become tolerant of the cold. By mid-winter, most larvae can withstand -40°C for short periods. For cold temperatures to have their biggest impact on mortality, they have to come early or late in the season, when the beetle is least tolerant. Also, the cold temperatures must persist for several days because, with insulating bark and snow, it can take some time before temperatures under the bark decline to levels lethal to the beetle.

Cooler than average summers will delay or extend the annual mountain pine beetle flight, making overwintering larvae slightly more susceptible to cold weather. Cool summers also result in fewer beetles attacking trees at any one time, thereby making attack less effective.

Wildfire: Fire is a natural part of the forest ecosystem. Wildfires can leave a patchwork of age classes which tends to control the beetle. However, over the last several decades, wildfires have been fought effectively, providing safety for communities and saving valuable timber. An unintended consequence of fire suppression is an older forest without the age-class mosaic which would naturally occur. Large

Site index: A relative measure of a forest site's potential to grow timber based on the average height of the dominant trees at a specific age (usually 25 or 50 years).

Over the last several decades, wildfires have been fought effectively resulting in older forests that can be more susceptible to mountain pine beetle outbreaks.

DBH (diameter at breast height):

The stem diameter of a tree measured at breast height, 1.3 metres above the ground.

contiguous stands of susceptible trees (older than 60 years or greater than 25 cm in diameter) favour epidemic-scale populations.

The Infestation Cycle

The Endemic Population: The endemic population is the usual or normal state that exists between mountain pine beetle outbreaks. Endemic populations exist mainly in single trees that are weakened. Poor stand conditions help maintain these populations. At the endemic level, mountain pine beetle attacks are somewhat difficult to find because the insect often breeds in trees attacked by other bark beetle species.

In endemic mountain pine beetle populations, attacked trees are often not located near brood trees, and yearly tree mortality is normally less than volume growth. There is not much year-to-year change in population and damage levels because reproduction and brood mortality are in balance. In endemic populations, brood mortality is as high as 97%, so population levels don't increase.

Host resistance, natural enemies (e.g., predators and diseases), weather, and competition for food and space are factors which interact to limit mountain pine beetle populations during endemic conditions. A change in any one of these factors could result in an outbreak.

The Incipient Population: Populations large enough to overcome the resistance of a stand's average large-diameter tree are considered incipient populations. Brood survival in large DBH trees is higher than in smaller trees due to nutritional and physical reasons such as thicker phloem and reduced mortality from drying of the bark or cold temperatures. Incipient infestations can develop either because tree resistance is reduced or because brood survival has increased as a result of favourable weather conditions.

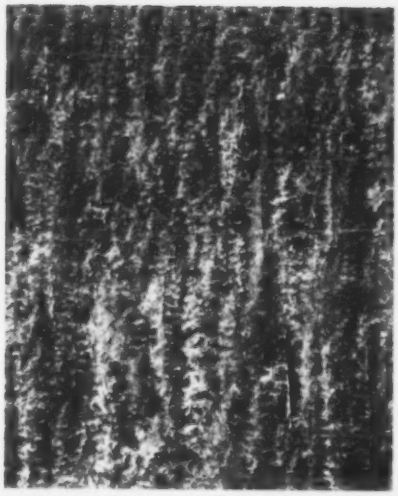
Initially, incipient populations grow slowly and populations and infestation levels may not even double in successive years, so infestations may not be noticed for a number of years. In incipient populations, most of the attacked trees are in the larger-diameter classes and the number of infested trees usually increases annually. Clumps of infested trees grow in size and number over time, and infestations are scattered and confined in individual stands. Incipient infestations often develop when trees are stressed by factors such as crowding, drought, or periodic flooding.

The Epidemic Population: During epidemics, populations exist at the landscape level as a result of local population growth and within-stand and long-range dispersal. Incipient infestations grow into epidemic outbreaks as groups of infested trees join together into larger patches and new infestations develop yearly through a combination of within-stand and long-range dispersal. The main causes of epidemics are (a) sustained favourable climate for mountain pine beetle survival such as a series of mild winters and good weather during the dispersal and attack periods and (b) abundance of pine of susceptible age, size and physical condition.

Epidemics are not confined to individual stands, but extend over wide areas of landscape. There are large annual increases in infested areas, and epidemic populations are very resilient to normal mortality, often rebounding following large-scale mortality. During epidemics brood mortality is in the range of 80% to 95%. This level of brood survival — 5% to 20% — results in a two- to eight-fold annual increase in population and damage levels.

Large mountain pine beetle populations are able to colonize remnants of susceptible lodgepole pine stands, such as strips of old pine among younger trees. During epidemics, there is a strong relationship between DBH and tree mortality. On average, there is a 1.5% to 4% increase in tree mortality with each centimeter increase in DBH above 10 cm. Consequently, trees in the dominant and co-dominant size classes will suffer the heaviest mortality.

The causes of epidemic collapse are depletion of susceptible stands and adverse climatic conditions. In the final phases of epidemic decline, other mortality factors, such as secondary bark beetle species, woodpecker predation and degradation of host suitability, may also play a role in epidemic collapse.



Incipient infestations often develop when trees are stressed by factors such as crowding, drought or periodic flooding.

Epidemics extend over wide areas of landscape.

Stand Susceptibility

Stand susceptibility is the degree of vulnerability to damage of the stand as a whole in the event of a mountain pine beetle infestation. The inherent characteristics of a stand affect its ability to withstand attack without incurring serious damage or injury. Such stand characteristics include density (number of trees per hectare) and composition (ratio of tree species, age and size), and site characteristics (such as temperature, moisture regime, slope and aspect).

Age: Older trees are more susceptible to the mountain pine beetle as they are less able to produce much resin (their main defence mechanism) and older trees tend to be bigger and easier to find. The most susceptible stands are the dominant and co-dominant lodgepole pine that have an average age of more than 80 years.

Density: Moderate-density stands are more susceptible because (a) low-density stands produce more vigorous (resistant) trees (b) low-density stands have a less favourable microclimate and (c) high density stands produce smaller trees with thin phloem and bark. The most favourable stand densities for the mountain pine beetle are between 750 and 1500 stems per hectare with DBH greater than 7.5 cm.

Species composition: Stands with a lot of large-diameter lodgepole pine are more susceptible because (a) pine is the primary host, and (b) more pine in the stand means a higher probability that a beetle in flight will encounter a suitable host tree.

Tree size: Large trees are more susceptible. Successful attacks begin between 10 and 15 cm DBH, increasing by 1.5% to 4% with each centimeter of DBH. Large pine trees have thick bark which offers protection from weather and predators and they usually have thick phloem which provides more feeding and breeding material.

Site Factors: Mountain pine beetles are most successful when temperatures permit a one-year life cycle. Temperatures are modified by latitude, longitude, elevation, slope and aspect. Temperatures decrease with increasing latitude and elevation, and from a west to east direction. Southern aspects are generally significantly warmer and drier than northern aspects, and this effect is amplified by sun angle on steeper slopes. Soil moisture affects the degree to which trees are drought stressed. Stressed trees have limited capabilities to produce the resin necessary to 'pitch' out the invading beetle.

Pine susceptibility: Pine susceptibility is defined as the inherent characteristics of the pine component of a stand which affect its likelihood of mountain pine beetle attack and damage. Individual pine trees in a stand may be highly susceptible to mountain pine beetle but if they do not comprise a significant portion of a stand then the stand will not be highly susceptible.

A highly susceptible stand, by definition, will have a high percentage of large-diameter lodgepole pine. It will have both a high stand susceptibility and high pine susceptibility. A stand with a lower

susceptibility rating may still have some susceptible pine, but it may not represent a significant component of the total stand basal area. The rest of the stand may not be a susceptible species or may be younger pine which are not susceptible. The mountain pine beetle may attack the pine, but may not kill a significant portion of the total basal area of the stand. Such a stand will have a low stand susceptibility but a high pine susceptibility.

Susceptibility ratings (stand and pine) are generally used for long-term forest management purposes. These ratings indicate the characteristics of the stand and the trees, and generally do not change suddenly.

One year after attack by mountain pine beetles, host trees fade to red. Within two years the needles fall.

Stand Risk

Stand risk in the context of the mountain pine beetle is defined as the short-term probability of tree mortality in a stand as a result of an infestation. It is a combination of stand susceptibility and mountain pine beetle pressure (the magnitude of a mountain pine beetle population and its proximity to a susceptible stand).

Pine risk is defined as the short-term expectation or probability of pine tree mortality in a stand as a result of a mountain pine beetle infestation. Risk ratings (stand and pine) are used for short-term forest health management. They reflect the current mountain pine beetle situation and will change annually.

Although mountain pine beetles attack mature, larger-diameter trees, epidemic outbreaks initially occur in less healthy, old stands. As more trees become infested, the beetle population increases and spreads to healthy and progressively smaller trees. As a result, huge areas of lodgepole pine may be killed.

The mountain pine beetle is a natural part of the forest ecosystem at endemic levels. Currently, populations are at epidemic levels as a result of mild winters and an abundance of large stands of mature pine.

Mountain Pine Beetle Management

Successful forest health management begins with annual monitoring for forest health problems such as the presence of mountain pine beetles, and integrating forest health provisions into forest management plans. Some management practices help to prevent or disrupt conditions favourable to particular pests in your woodland. In the case of mountain pine beetle such practices may include managing stands for a mixture of species and age classes, harvesting susceptible stands on a priority basis (e.g., over-mature trees; larger trees on south-facing slopes; trees or stands adjacent to known infestations; sites of previous infestations), maintaining clean logging practices, and practicing sanitation cutting to remove infected trees. In many cases prevention and control can be incorporated into other activities on your woodland such as harvesting, thinning, or regeneration.

First Steps – Looking for Problems

Forest pests are a part of natural forests, and most often their populations are at levels that do not result in significant losses to timber values. Insect pests, including mountain pine beetle, can become a problem when conditions in the forest environment cause particular trees to become more vulnerable to attack and trigger a population outbreak. For small-scale woodland owners, prevention and control of bark beetle problems may be more complex or difficult when lands adjacent to the woodland are also infested. On the other hand, a smaller area tends to be more accessible and an infestation might be detected earlier on a small woodlot.

These are the first steps for dealing with possible mountain pine beetle problems:

- Learn how to identify the mountain pine beetle.
- Find out if the mountain pine beetle is currently active within your region or in a region adjacent to your woodland.
- Identify the susceptible lodgepole pine stands within your woodland.

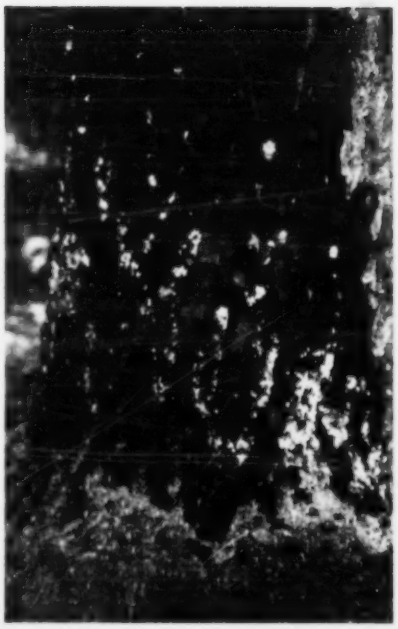
This information will provide you with a better understanding of where the mountain pine beetle is likely to attack and how much of your woodland is at risk. **But it is important to call your local provincial or federal government forestry office and tell them you'd like help managing forest health problems. Ask them for**

information about the mountain pine beetle risk in your area and get advice about how your particular woodland area fits within their beetle management strategy. See the back of this guide for contact information.

What Do Infested Trees Look Like?

External evidence of beetle infestation includes reddish boring dust at the base of attacked trees and pecking holes or bark removal made by feeding woodpeckers. Trees respond to attack by releasing resin which mixes with the boring dust and forms a soft, white or reddish pitch tube around each bore hole.

After a tree is attacked, foliage turns from bright to dull green to yellow and rusty-brown by spring of the next year. Once a tree's foliage turns red in the early summer of the year following attack (known as "red attack"), most beetles usually have moved on to another tree or even another area. Most of the needles drop from the tree after two years, leaving a gray snag.



Most of the brown boring dust at the base of this lodgepole pine was made by the mountain pine beetle.

Preventing Beetle Damage

Prevention strategies involve proactive measures to reduce stand susceptibility in your woodland. To plan an effective prevention strategy, susceptible stands will need to be identified. Based upon susceptibility, determine the relative hazard levels of your stands that contain lodgepole pine, and use this knowledge to develop a harvest plan that minimizes and disperses the susceptible stands within your woodland. In circumstances where mountain pine beetle is present in adjacent or nearby areas, relative risk ratings should be used in place of hazard ratings. Risk rating of your stand is best conducted annually based on the proximity of known infestations in the region, as mountain pine beetle flights are known to reach up to 40 kilometers. These precautionary measures may help you prevent a mountain pine beetle infestation from becoming established.

The most effective way to prevent a mountain pine beetle infestation is to harvest mature lodgepole pine stands before they become overmature and susceptible. But it is often not possible or practical to remove all mature lodgepole pine stands. In these cases, strategic placement of harvesting blocks can be used to create a dispersed pattern of susceptible stands, thus reducing risk of infestation.

Pitch tubes on a lodgepole pine are external evidence of beetle activity within the tree.

Woodpeckers will pick out the tree with the best mountain pine beetle brood and therefore are good indicators of beetle attack.

Other specific measures that you might consider to prevent mountain pine beetle infestations from occurring include:

- Developing an access plan to allow greater flexibility for timely treatment or harvest scheduling.
- Encouraging insectivorous birds by maintaining active nest trees and keeping some of the larger dead trees as nest trees. Woodpeckers, for example, can aid in maintaining beetle populations at low levels.

Rehabilitating Damaged Sites

Sometimes a stand is not merchantable but is suitable for rehabilitation. If this is the case with your woodland, this can be an opportunity to enhance its value. An example of this is when the damaged area is adjacent to a reforestation site where activities such as site preparation and planting can be expanded to include the beetle-killed site.

Rehabilitation involves basic reforestation such as site preparation (may require felling and burning), selection of tree species to plant, and selection of planting stock types.

Natural Succession and Non-Timber Values

You should consider all forest values when developing an action plan for your property. Serious consideration needs to be given to protect all values such as timber, soils, riparian areas, other habitat features, and berry-picking areas.

You may consider abandoning control activities if there are areas where management efforts are ineffective in substantially reducing the beetle population and subsequent levels of damage, or where control measures are prohibitively expensive. From a control perspective it is preferable to destroy brood trees containing active mountain pine beetles. If this strategy is seen as futile because adjacent areas are already infested, or there is little risk of subsequent infestation, then there is little value in destroying brood trees. In some instances these trees can provide for other non-timber values such as habitat and biodiversity features. However, abandoning a portion of the woodland may lead to expansion of the infestation into other areas. **Therefore, it is important to consult your local government office to see which option is best suited to your woodland as well as your region.**

Abandoning a site to natural succession does not necessarily mean a long-term abandonment. A later assessment could result in a different decision.

Destroying the Brood Trees

The early stage of mountain pine beetle infestation starts with isolated spots or groups of infested trees. In areas containing low levels of infestation in scattered or spot attacks, individual infested trees can be removed using single-tree treatments. The success of this strategy depends on early and complete detection of attacked trees. Infested trees should be treated while the brood are still present and well before the dispersal flight in the spring following attack. The treated sites should be inspected the following year to determine the success of the treatment and to identify trees that may still require treatment. If the adjacent levels of infestation are severe they may spill over into the area that was sanitized the year before by single-tree treatment.

When the preferred treatment is to destroy individual brood trees there are two common options:

- Fall brood trees and burn all portions that contain live beetles.
- Fall brood trees and mechanically destroy beetles and bark.

Fall and Burn: Fall and burn involves felling, bucking, piling and burning infested portions of pine trees during the winter months to destroy live beetle brood. Fall and burn is usually selected as a treatment when the number of attacked trees is low and there is insufficient volume to warrant harvesting, or if the cost of harvest is prohibitive.

It is also used in areas where other constraints (for example, steep slopes, stream protection, important wildlife habitat or poor access) limit removal options. There are always risks associated with the use of fire in forest management. **Be sure you are aware of the risks and regulations and know your legal obligations.**

Discoloured foliage is a sign that these lodgepole pines have been attacked by the mountain pine beetle.

Mineral Soil: Soil consisting predominantly of inorganic matter. The texture of mineral soil determines its soil-moisture-holding capability. Coarse soils hold moisture poorly. Silty, loamy, and clay soils retain moisture well.

When conducting fall and burn treatments, make sure you:

- Assess the attacked tree for live beetles by using an axe to expose the cambium. This can be done with the tree standing or by felling the tree and then assessing it on the ground.
- Treat the portion of the tree showing sign of infestation to at least 1 m above the last sign of the beetle. Fell, buck, pile and burn all infested portions of the tree around the tree stump and ensure that all infested bark is well burned.
- Bark remaining on the unburned portion of the stump should be peeled to the point where the stump intersects with the mineral soil.

Some of the key points to consider with a fall and burn treatment include:

1. Access: Fall and burn can be used to treat sites that are not easily accessible by road but can be reached by workers on foot, all-terrain vehicle or snowmobile. Fall and burn is more difficult in inaccessible sites. The feasibility of this treatment is limited by how far the crew can walk beyond motorized access; this is generally no more than 3 km.
2. Tree Size: Operational costs are directly related to tree size as both bucking and piling are labour intensive activities. Tree sections need to be carried and piled over the stump by hand for burning. It takes more time to process larger trees due to the amount of labour involved.
3. Timing: The window of opportunity for this treatment is restricted to acceptable burning days after the beetle flight ends and prior to the start of the next flight. Work generally should be completed by the end of March and sites should be re-examined in the spring to ensure that there are no persisting fires.
4. Snow depth: Beetles overwinter in significant numbers in the lowest part of the tree trunk. Thus, stumps must be thoroughly burnt or debarked. Deep snow can make stripping or burning the bark from stumps more difficult and time-consuming.
5. Advantages: Fall and burn can be effective where sufficient beetles are killed to prevent infestations from spreading.
6. Disadvantages: **Fall and burn poses risk of injury to adjacent trees as well as forest workers, and there is a risk of holdover fires.** Regulatory requirements and smoke management (if adjacent to communities) can be significant issues.

Fall and Debark: This treatment is recommended where field conditions are unsuitable for fall and burn operations. Fall and debark procedures are similar to fall and burn procedures except that bark is removed from trees instead of being burned in place. There are two ways of debarking: hand debarking and mechanical debarking.

Hand debarking is generally slower than burning and can be more costly. Hand debarking is normally done during the summer months for two reasons: bark is relatively loose during the growing season but tightens with cold weather, making it more difficult to remove; and it is impractical to burn during the summer season. As with fall and burn, debarking gets more difficult and time-consuming as tree size increases. Fall and debark treatments can have an advantage over fall and burn in that they can be conducted early in the beetle season as infestation sites are discovered, and the treatment will destroy late emerging beetles.

Mechanical debarking is faster than hand debarking and can be similar in cost to fall and burn. All other aspects are similar to hand debarking. Mechanical debarking is normally done with a motorized flail that pulverizes beetles and bark at the same time. Peeled bark will normally dry and cause beetles that are not fully developed to desiccate and die. Peeling also exposes mountain pine beetle to predators such as birds and ants. Beetles that are fully developed will likely fly even if the bark is peeled, so it is important to check the stage of development. Peeled bark should be spread to encourage drying.

Needles on separate branches of the same attacked tree may discolour at different times.

Holding for Future Harvest

If harvesting your woodland is not viable now, the best strategy may be to hold for future harvest.

The 'holding' strategy uses chemical means to kill beetles in brood trees or to control their spread for a short period of time (control can be for one to several years, depending upon the option chosen). The intent is a temporary delay to allow for definite harvest plans to be put in place. Harvest can be delayed for a number of reasons: timing of access development, unsuitable log markets, unavailable contractors, or seasonal operating restrictions. If you are attempting to contain an existing infestation, the infestations should be harvested in two to three years, depending on the hazard and risk of the area.

Two chemical treatments can be used to implement a holding strategy: pheromone baiting to attract the colonizing beetles to the trap trees;

and pesticides to kill colonizing beetles and larvae. Pheromone treatment is part of a short-term (less than one year) holding strategy that is not appropriate for small woodlot areas. (If pheromone baits are used, there must be a commitment to harvest before the next beetle flight or there will be an increased risk of mountain pine beetle infestation.) Pesticide use is a longer-term strategy.

Pesticides may be a cost-effective way to contain or eradicate single trees or small outbreaks where the stand can't be harvested before the next flight. Monosodium Methanearsonate (MSMA) is a registered pesticide and must be applied to the bole of the tree. To be effective, it must be injected into a cut or frill made into the sapwood with an axe, low on the base of the infested tree. This must occur within 4 weeks of mountain pine beetle attack. The tree must still have enough life left in it to transport the material up the bole using its natural processes of moisture and nutrient flow. MSMA kills beetle larvae living in the treated tree. Apply or inject MSMA into the frill at a rate specified by the pesticide label.

Some operational considerations to be aware of include:

- Time and cost of obtaining approvals or permits.
- Cost of application and implementation.
- Risk to workers.
- Conflicts with other resource users.
- Environmental risks.
- Restrictions that determine who can apply for pesticide-use permits.
- The short treatment window.

Due to the contentious nature of pesticide treatments, seek the advice of local forestry or environment officials. Permits or approvals from government agencies are required.

Removing Stands Using a Salvage Harvest

Salvage harvesting might be used where beetle populations can be better contained by removing both infested and susceptible stands. It might also be appropriate for areas where management efforts would be ineffective and the focus is to salvage value from a woodland.

Small-Patch Harvesting: Small-patch harvesting is employed when salvage harvesting with normal cut patterns would produce an excess of harvested timber, or where there is another reason to minimize harvest rates. Small areas of concentrated attack are identified and scheduled for harvesting while unattacked areas between the patches are left. Generally, harvest openings are one to several hectares in size. The advantage of small patches over single-tree removal is generally lower harvesting costs. The disadvantages of small-patch harvesting compared to large-patch harvesting are that repeated treatments are often required and there are more road construction costs.

Large-Patch Clearcutting: Large patch harvesting is used where normal harvest patterns can be strategically placed to salvage all merchantable beetle-killed timber without exceeding the planned harvest volume. The woodland manager includes infested patches and the unattacked timber in a common opening. The advantages of larger-patch harvesting are reduced costs and reduced road densities.

Partial cutting treatments can decrease stand susceptibility to mountain pine beetle attack.

Maintaining Stands With a Sanitation Cut

Is single-tree harvesting viable on your woodland? If so, the best strategy may be to maintain the stand with a sanitation cut.

As mentioned above ("Destroying the Brood Trees") the early stage of mountain pine beetle infestation starts with isolated spots or groups of infested trees. In areas containing low level, scattered or spot attacks, individual infested trees can be removed using single-tree treatments. The success of this strategy depends on early and complete detection of attacked trees. The treated sites should be inspected the following year to determine the success of the treatment and to identify trees that may still require treatment. If the adjacent infestation levels are severe, the infestation may spill over into the area that was sanitized the year before by single-tree treatment; where this is reasonably certain, single-tree harvest may be abandoned for salvage harvest in a subsequent year.

Priority trees to be harvested are in stands with the highest levels of new infestation and/or the highest risk of spreading. The following are important considerations when planning single-tree harvest operations:

- Usually trails are used to access infestations.
- Costs increase as skid distance increases.
- Trail width is generally kept as narrow as possible, usually 5 - 6 m.
- Trail area must be considered in harvest plans.
- Timber is skidded to an existing road where it can be loaded and hauled.

The advantages of single-tree harvest operations are the amount of the timber removed is minimized, the operation creates trails which may be used repeatedly for future sanitation cuts, and small openings left after harvesting may regenerate naturally. The disadvantages are that this harvesting technique is expensive, single-tree gaps and trails result in an under-utilized growing site, and there may be damage to trees along trails.

Reforestation

When the mountain pine beetle management strategy selected is to harvest (salvage harvest or sanitation cut) or to rehabilitate your woodlands, the next steps will include developing and implementing a reforestation strategy. A reforestation strategy ensures that the key elements of reforestation are considered before harvest.

Key points to remember about regenerating lodgepole pine:

- Lodgepole pine has low shade tolerance. Thus, under-planting will not usually be successful in partial cut stands. Full sunlight found in clearcuts is preferred (lodgepole pine is a pioneer species).
- It has moderate to high frost tolerance.
- It requires exposed mineral soil for natural regeneration.
- It prefers drier sites rather than moist to wet sites.
- It will grow on sites having poor to medium nutrient availability.

For a guide to species selection see *Regenerating British Columbia's Forests*, and for information regarding stock type, check the BC Ministry of Forests' *Provincial Seedling Stock Type Selection and Ordering Guidelines*. See the back of this guide for more information on these publications.

What to Do with Your Wood

To sell your wood, contact local mills and log yards, watch the local paper for advertisements from log buyers and brokers, and talk to the logging contractor that you hired. It is best to begin your inquiries before harvesting your trees or stands.

Buyers might include:

- **Local Sawmills** – Contact the sawmills in your area and arrange to meet with their log buyers.
- **Log Brokers** – Log brokers buy and sell logs. They may sell on commission, or purchase to re-sort, re-package or process into value-added products. Contact information is available from local companies, the yellow pages, and industry associations.
- **Logging Companies** – There are some logging companies that buy timber from small-scale woodland managers to keep equipment busy during off-seasons. Most logging contractors will know where wood is going because they deliver it, and will generally know the prices being offered. Contact information is available from the Truck Loggers Association and local woodlot associations.
- **Specialty Wood Manufacturers** – Specialty wood manufacturers may have very specific wood needs. Most value-added manufacturers use processed wood products such as boards and panels. However, some may occasionally buy logs for custom milling. Pole and log building manufacturers also purchase specialty logs.

Unfortunately, the death of a lodgepole pine from the mountain pine beetle and the blue stain fungus has three main effects:

- There is rapid loss of moisture from the sapwood.
- The blue stain fungus and the pigment it produces spread throughout the sapwood.
- Checks and splits develop as the wood dries.

The blue stain begins to spread shortly after successful attack of the tree and eventually invades most of the sapwood. During the first year of attack, the moisture content of the sapwood can be as low as 40% of normal. The process of checking and splitting can begin as early as the year after attack (as the outer sapwood dries) and continues over the next few years as foliage is lost and the bark becomes loose and falls off.

Lumber recovered from beetle-killed timber has been used primarily as framing material. Although there may be a niche market for blue

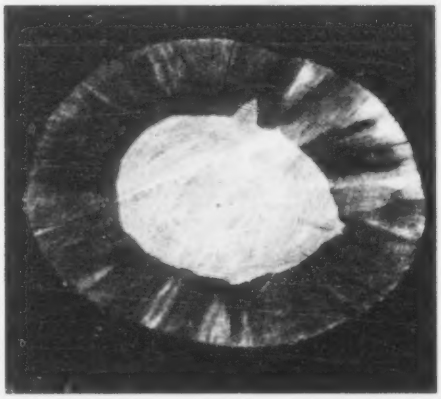
An example of an area that has been logged as a means of mountain pine beetle control.

stained wood among people who find it visually appealing, the colouration will limit its use as a finishing wood product and in some markets.

With the support of the Canadian Forest Service and the Mountain Pine Beetle Initiative (described on page 2), Forintek Canada has found the heat in kiln drying (often a part of the lumber production process) destroys fungi in the wood. They have also determined that blue stain has no practical effect on strength properties, gluing characteristics, or the adhesion of furniture finishes. The Pulp and Paper Research Institute of Canada, Forintek Canada, and the University of BC, with funding under the Mountain Pine Beetle Initiative program, are studying both beetle and blue stain effects on timber processing properties and product qualities. The goal of this research is to integrate efficient utilization of beetle salvage timber into established products and markets.

Forest Management Planning

Forest management is a long-term process and most management decisions have long-term implications. Timber crops take many years to develop and your actions need to be well planned. For example, road systems must be designed to access timber with the least loss of productive land over entire rotations. In addition, reforestation plans should go beyond establishment of plantations to ensure that new forests will reach maturity. Harvesting plans need to consider both what is removed and what is left behind from the perspective of forest health, wind firmness, and future operability. Timber harvesting, in itself, involves many steps – buyers must be found, equipment scheduled, contracts arranged, and products delivered. Proper planning helps you avoid unnecessary steps, costs, and delays.



The sapwood on this lodgepole pine disk has been discoloured by the blue stain fungus.

Woodland management planning includes both long-term stewardship goals and short-term operational goals. Often, smaller land holdings have the two levels of planning – a strategic management plan for long-term stewardship goals and a shorter-term operational plan for specific management activity – combined into one plan.

Management Plans

A stand-alone stewardship plan documents your goals for the land holding and how you plan to achieve them. It consists of a written section and one or more accompanying maps. A management plan will be required if you (or the woodland manager) intend to apply for certification of management on the woodland for marketing purposes. The written section usually includes:

- a general description of the property;
- your personal goals for the property;
- measurable long-term management objectives; and
- your short-term tactics with respect to longer-term objectives.

Where a single plan approach is preferred, it can include operational information in addition to the above strategic and tactical points:

- proposed management standards and guidelines; and
- a description and schedule of proposed short-term operational activities.

The map (or maps) should highlight the boundaries of the woodland property, the forest cover and other resources within it, the physical

features, past development history, road access, and the proposed development activities for the planning period (usually five years).

The forest management plan should be reviewed and updated every five years to incorporate changes in the woodland and in any of the proposed activities. A plan is recommended for woodlot licencees, and private and First Nations lands.

Examples of long-term management objectives might be to maintain long-term resistance to mountain pine beetle in the land holding, and to maintain or enhance the value of the assets (especially timber) on the woodland. Short-term objectives might include annual harvesting schedules and layout to deal with stands and trees susceptible to mountain pine beetle. If your woodland is likely to be attacked by the mountain pine beetle, your management plan will likely have a time management focus.

Operational Plans

Stand-alone operational plans provide details on specific treatments and the schedule of activities planned to meet long-term objectives (including maintaining low mountain pine beetle susceptibility in your stands), or to meet shorter-term needs (removal of mountain pine beetle attacked trees or stands). The operational plan may include surveys, probing, harvest layout, treatment plans, permit applications and obtaining a timber mark. Where the mountain pine beetle is epidemic, the operational plan will change at least annually.

Your Obligation to Manage

If the BC Ministry of Forests or the Alberta Ministry of Sustainable Resource Development determine that there are insects, diseases, animals, or abiotic factors which are causing damage to your forest, you may be required to propose reasonable measures to control or dispose of them within a specified time. **Prior to harvesting or starting related activities on your woodland, contact your local provincial government office to obtain regulations related to private woodlands.**

Regardless of the laws and the nature of your holding, practice basic stewardship in your harvesting and forest management activities. Forest health management requires a team effort among district managers, forest licencees and private land managers, no matter how small the operation.

Obtaining Help

Use the sources below to find more information about the mountain pine beetle. Contact the forest health professionals in your area and check the web sites, many of which contain user-friendly maps and images that will provide help managing mountain pine beetle on your woodland.

Forest Health Contacts

British Columbia

Canadian Forest Service, Natural Resources Canada
Forest health research; forest insects; forest diseases; forest health management
Mailing address: 506 West Burnside Road, Victoria, BC V8Z 1M5
Telephone: (250) 363-0600 or 1-888-255-7041
Fax: (250) 363-0775
Web site: www.pfc.cfs.nrcan.gc.ca
Employee directory: www.pfc.cfs.nrcan.ca/profiles/index_e.html

Ministry of Forests – Branches, Regions, and Districts
Forest health management; forest insects; forest diseases
Main mailing address: PO Box 9529, Stn Prov Govt, Victoria BC V8W 9C3
Telephone: (250) 387-6121 or 1-800-663-7867
Web site: www.gov.bc.ca/mof

University of Northern British Columbia – Forestry Program
Forest health research; forest insects; forest diseases; forest health management
Mailing address: 3333 University Way, Prince George, BC V2N 4Z9
Telephone: (250) 960-5555
Fax: (250) 960-5539
Forestry program web site: www.unbc.ca/forestry

University of British Columbia – Faculty of Forestry
Forest health research; forest insects; forest diseases; forest health management
Mailing address: Forest Sciences Centre, 2424 Main Mall, Vancouver, BC V6T 1Z4
Telephone: (604) 822-2727
Fax: (604) 822-8645
Web site: www.forestry.ubc.ca

Alberta

Canadian Forest Service – Natural Resources Canada
Forest health research; forest insects; forest diseases; forest health management
Mailing address: 5320–122 Street, Edmonton, Alberta T6H 3S5
Telephone: (780) 435-7210
Fax: (780) 435-7359
Web site: www.nofc.cfs.nrcan.gc.ca
Employee areas of responsibility: www.nofc.cfs.nrcan.gc.ca/people/areas_of_resp_e.html

Ministry of Sustainable Resource Development – Lands and Forests Division
Forest insects; forest diseases; forest health management
Mailing address: Information Centre, Main Floor 9920–108 Street,
Edmonton, Alberta T5K 2M4
Telephone: (780) 944-0313
Fax: (780) 427-4407
Web site: www3.gov.ab.ca/srd/forests

University of Alberta – Department of Renewable Resources
Forest health research; forest insects; forest diseases; forest health management
Mailing address: 751 General Services Building, Edmonton, Alberta T6G 2H1
Telephone: (780) 492-4413
Fax: (780) 492-4323
Web site: www.rr.ualberta.ca
Centre for Enhanced Forest Management: www.rr.ualberta.ca / Research/EFM/silviculture_reclamation.htm

Useful Web Sites

British Columbia

Canadian Forest Service, Pacific Forestry Centre: Mountain pine beetle web sites
www.pfc.cfs.nrcan.gc.ca/entomology/mpb
mpb.cfs.nrcan.gc.ca

BC Ministry of Forests
Forest Health
www.for.gov.bc.ca/hfp/forsite/Forest_Health.htm

BC Legislation and Regulations
www.legis.gov.bc.ca/legislation/index.htm
www.for.gov.bc.ca/tasb/legsregs/amendlog.htm

Forintek Canada Corporation
www.forintek.ca

Pulp and Paper Research Institute of Canada
www.paprican.ca

Small Woodlands Program of British Columbia
Small woodlands business planning and marketing guidebook (2002)
www.cnc.bc.ca/LIBRARY/smallwoodland.html

Private Forest Landowners Association
www.pfla.bc.ca

The Truck Loggers Association of BC
www.truckloggers.com

The Association of BC Forest Professionals
www.rpf-bc.org

University of BC Faculty of Forestry
www.forestry.ubc.ca

Alberta

Canadian Forest Service, Northern Forestry Centre: Mountain pine beetle web site
www.nofc.cfs.nrcan.gc.ca/publications/leaflets/mpb_e.html

Alberta Government, Sustainable Resource Development, Forests
www3.gov.ab.ca/srd/forests

Forest Health Pest Alerts
www3.gov.ab.ca/srd/forests/health/mpb_2003.html

College of Alberta Professional Foresters
www.professionalforesters.ab.ca

Forintek Canada Corporation
www.forintek.ca

Pulp and Paper Research Institute of Canada
www.paprican.ca

University of Alberta Faculty of Agriculture, Forestry and Home Economics
www.afhe.ualberta.ca

Woodlot Association of Alberta
www.woodlot.org

Useful Publications

Publications marked with an asterisk are available through the Canadian Forest Service bookstore at bookstore.cfs.nrcan.gc.ca.

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Bancroft, B. 1992. Fundamentals of natural lodgepole pine regeneration and drag scarification. BC Ministry of Forests, Forest Renewal Section, Forest Practices Branch, Victoria, BC. pp. 3-8, 13-17.

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* Henigman, J.; Ebata, T.; Allen, E.; Holt, J.; Pollard, A. 1999. Field guide to forest damage in British Columbia. BC Ministry of Forests and Canadian Forest Service, Victoria, BC. Joint Publication 17. 348 p.

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Lemaster R.L.; Troxell, H.E.; Sampson, G.R. 1983. Wood utilization potential of beetle-killed lodgepole pine for solid wood products. Forest Products Journal 33(9): 64-68.

Logan, J.A.; Powell, J.A. 2001. Ghost forests, global warming, and the mountain pine beetle (Coleoptera: Scolytidae). American Entomologist 47 (3): 160-172.

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* Natural Resources Canada, Canadian Forest Service. 2002. Managing your woodland: a non-forester's guide to small-scale forestry in British Columbia. Co-published by the Small Woodlands Program of BC and the Canadian Forest Service, Victoria, BC. 303 p.

Nielson, R.W. 1986. Harvesting and processing of beetle-killed timber. Proceedings Seminar Sponsored by Forintek Canada Corp. and COFI, Northern Interior Lumber Sector, May 10, 1985, Prince George, BC. Forintek Special Publication No. SP-26. 53 p.

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* Safranyik, L.; Barclay, H.; Thomson, A.; Reil, W.G. 1999. A population dynamics model for the mountain pine beetle, *Dendroctonus ponderosae* Hopk. (Coleoptera : Scolytidae). Pacific Forestry Centre, Canadian Forest Service, Victoria, BC. Information Report BC-X-386. 35 p.

* Safranyik, L.; Linton, D.A. 1998. Mortality of mountain pine beetle larvae, *Dendroctonus ponderosae* (Coleoptera: Scolytidae), in logs of lodgepole pine (*Pinus contorta* var. *latifolia*) at constant low temperatures. Journal of the Entomological Society BC 95: 81-87.

* Safranyik, L.; Linton, D.A. 2002. Line transect sampling to estimate the density of lodgepole pine currently attacked by mountain pine beetle. Pacific Forestry Centre, Canadian Forest Service, Victoria, BC. Information Report BC-X-392. 10 p.

* Safranyik, L.; Linton, D.A.; Shore, T.L. 2000. Temporal and vertical distribution of bark beetles (Coleoptera: Scolytidae) captured in barrier traps at baited and unbaited lodgepole pines the year following attack by the mountain pine beetle. Canadian Entomologist 132: 799-810.

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* Safranyik, L.; Shrimpton, D.M.; Whitney, H.S. 1980. Management of lodgepole pine to reduce losses from the mountain pine beetle. Northern Forest Research Centre, Forestry Service, Environment Canada, Edmonton, Alberta. Forest Technical Report. 24 p.

Scagel, R.K.; Bowden, R.; Madill, M.; Kooistra, C. 1998. Provincial seedling stock type selection and ordering guidelines. BC Ministry of Forests, Victoria, BC. 71 p.

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Contact:

For more information on the Canadian Forest Service, visit our web site at:

www.nrcan.gc.ca/cfs-scf

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Victoria, BC V8Z 1M5
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www.pfc.cfs.nrcan.gc.ca

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